

SSPC: The Society for Protective Coatings

TECHNOLOGY UPDATE NO. 3

Overcoating

1. Scope

1.1 This technology update discusses the risks associated with the maintenance painting practice known as overcoating. Factors affecting overcoating application, service and costs are discussed.

1.2 This document is intended to serve as a resource for facility owners and others charged with developing and implementing maintenance painting programs.

1.3 Overcoating is one of several maintenance painting options. This document is not intended to provide a detailed description or comparison of the relative merit and cost considerations of overcoating versus other maintenance painting options. For a more complete and detailed discussion of maintenance painting practices, the reader should refer to SSPC-PA Guide 5, Guide to Maintenance Painting Programs.

2. Description and Definitions

2.1 DESCRIPTION

2.1.1 This document contains discussions of the risks associated with overcoating, methods of assessing risk, and means by which risks may be managed and reduced.

2.1.2 Overcoating is generally defined as the practice of painting over an existing coating as a means of extending its useful service life. Overcoating may be a cost-effective alternative to complete coating removal and repainting. When the old coating contains lead, cadmium, or chromium, overcoating may be a particularly attractive option due to economic considerations. Overcoating presents certain risks as well (see risk definition below).

2.2 DEFINITIONS

For the purposes of this document, the following definitions will be used:

Coating stress: The tension that a coating has, which is capable of being imparted to the steel substrate or other coating.

Embrittled coating: Coating that has degraded to a friable condition but still has enough elasticity to adhere to the substrate or existing coating.

Flaking: The detachment of small pieces of the coating film, usually preceded by cracking, checking or blistering.

Loose coating: Coating that has delaminated and disbonded from the substrate or other coats, but has not fallen off.

Marginally adherent coating: A coating that exhibits tape adhesion of 2A or less (per ASTM D 3359), such that the overcoating risk is moderate or high.

Overcoating: Application of coating materials over an existing coating in order to extend its service life, including use of the appropriate cleaning methods. The procedure includes preparation of rusted or degraded areas, feathering edges of existing paint, low-pressure water washing of the entire structure to remove contaminants, application of a full intermediate coat over repaired areas, and optional application of a full topcoat over the entire structure. Overcoating may be a cost effective alternative to complete coating removal and repainting. When the old coating contains lead, cadmium, or chromium, overcoating may be a particularly attractive option due to economic considerations. Overcoating presents certain risks as well.

Repaint: Complete removal of the existing coating system followed by application of a new coating system (including appropriate cleaning methods.)

Risk: As used herein, "risk" refers to the chance that the overcoated system (old paint plus newly applied overcoat) will either fail catastrophically (e.g., delamination of the system) or will not provide the desired period of protection (e.g., early rust back).

Spot repair: A procedure entailing surface cleaning of isolated corrosion or paint breakdown areas using appropriate cleaning methods, and subsequent coating of these areas.

Zone painting: A procedure entailing surface preparation using appropriate cleaning methods and painting of a defined area of a structure. Zone painting may involve (a) many spot repairs within a defined area or (b) removal of all coating in a defined area, followed by application of a new coating system to that area.

3. Discussion

3.1 RISKS ASSOCIATED WITH OVERCOATING

3.1.1 Delamination: A primary risk associated with overcoating is that the overcoating system could cause delamination. If a delamination failure occurs, the overcoating investment is lost. Delamination is difficult to predict; however, an understanding of the underlying principles will help the coatings engineer

reduce the chance of a delamination failure.

Delamination is primarily the result of internal stresses in the overcoat material being transferred to underlying or existing coating layers. Internal stress occurs as the applied paint shrinks. Several factors affect the degree of internal stress in the overcoat material, including the type of coating, the formulation, the film-forming conditions, the temperature and the coating's age and thickness. A good example of an increased internal stress is the oxidative curing of alkyds. Temperature fluctuations may also affect the level of internal stress. Brittle coatings are more apt to crack during temperature changes. The application of an overcoat may also affect the internal stress of the existing coating because the stress present in the overcoat is transmitted to the existing coating.

The internal stress of the overcoat is counteracted by its adhesion to the existing coating. A loss of adhesion of the existing paint system at either the steel/coating interface or within the layers of the existing coating may result in cracking of the overcoat.

Good overcoating systems should be designed so that there is higher tensile strength and rigidity in the existing or original coating than in the overcoat.

3.1.2 Early Rust Back or Poor Coating Performance:

Another primary risk involved in overcoating is that the system will not provide an adequate period of service. The overcoat may not experience a catastrophic failure, such as delamination, but nonetheless may fail prematurely because of the severity of the service environment. This type of degradation may be manifested by pinpoint rust, undercutting at small breaks in the coating system, or blistering. The amount and type of surface preparation used prior to applying the overcoat can also affect the degree of protection afforded by the overcoat material.

3.2 FACTORS AFFECTING RISK IN OVERCOATING

3.2.1 Influential Factors: The risk of delamination or other coating failure described in 3.1 is influenced by the condition of the existing coating, substrate factors, compatibility of new and old system, the type of structure and the exposure environment, etc.

3.2.2 Condition of Existing Coating

3.2.2.1 Existing Conditions: Visual and physical inspections, patch testing, and previous experience with similar systems for the expected exposure and conditions are proven tools in assessing the risk.

3.2.2.2 Existing Coating System Type (Oil, Alkyd, Vinyl, Epoxy, Urethane): It is important to be able to determine if multiple coating system types exist on the structure and to identify them in order to determine basic chemical composition, so that the proper overcoat system can be selected and special hazardous conditions can be identified.

3.2.2.3 Thickness: Thicker, aged coatings tend to be more highly stressed. Strong peeling forces can be generated during curing and aging of the overcoat. When overcoated, thicker, more highly stressed coatings are more likely to delaminate than thinner coatings with lower internal stress. Delamination may also be caused by thermal cycling that may disrupt the integrity of thick, aged coatings that have been overcoated. Rapid thermal cycling may accelerate system deterioration. Thicker, more highly stressed coatings are also more likely to sustain damage from blast media or other mechanical processes. This often results in a subsequent loss of adhesion that may affect the performance of the overcoat system.

3.2.2.4 Number of Coating Layers: Many layers of paint increase the chance of poor intercoat adhesion and may lead to delamination.

3.2.2.5 Coating Age: Depending on the curing mechanism, certain coatings tend to embrittle more with age than others. Alkyds are particularly susceptible to embrittlement with age.

3.2.2.6 Chalking and Erosion: Epoxy and alkyd coatings may chalk and erode with prolonged exposure. Generally this does not present a problem for overcoating as long as the loose chalk is removed prior to painting. Even severely eroded coatings with exposed primer may be good candidates for overcoating, provided the remaining coating has good adhesion and rusting is nominal.

3.2.2.7 Delaminated Paint Films: Paint films that exhibit delamination or other undesirable characteristics, such as cracking, are not good candidates for overcoating.

3.2.2.8 Coating Brittleness: Embrittled coatings tend to crack, providing sites for stress-induced peeling.

3.2.2.9 Coating Adhesion: The adhesion of the existing coating to itself and to the substrate is a critical factor. However, it is difficult to precisely define a satisfactory adhesion value. At present, adhesion is generally evaluated by either ASTM D 3359 or ASTM D 4541. Systems exhibiting low adhesion values in these tests are more likely to delaminate when overcoated than are aged coatings with higher adhesion values. Generally, the aged coating system will fail at its weakest point. Coating type, age, thickness, and surface preparation all affect the adhesion of the aged coating system.

3.2.2 Substrate Factors and Corrosion Pattern: The condition and type of the substrate under the existing coating system must be determined. Mill scale, because it is smooth and slick, generally presents the weakest point of adhesion of the coating, even if the mill scale itself is tightly adherent to the steel. Filiform rust or undercutting could continue beneath the film unless the source is removed. The condition of the substrate may affect the performance of the overcoat system. Generally, the more corrosion present, the higher the degree

of surface preparation required. This may cause localized problems on structures that were not cleaned uniformly prior to receiving the original coating. Localized rusted areas may dictate a different strategy than would spot rust over the entire surface area. There is a point at which it may no longer be cost-effective to overcoat.

3.2.3.1 Surface Preparation: The performance of the system is influenced by surface preparation prior to initial coating application. A surface that was previously blast cleaned is more likely to have satisfactory adhesion values, and is generally a better overcoat candidate, than a surface with existing mill scale.

3.2.3.2 Surface Contaminants: Surface contaminants, such as chloride and sulfates, can lead to decreased coating life and vastly accelerated corrosion, while grease and oil can result in poor wetting and adhesion of the overcoating system. Coatings differ widely in their ability to protect under these conditions. The problems associated with surface contaminants are not necessarily specific to overcoating; however, contaminants are less likely to be removed during overcoating because typically much less surface preparation is done. Less surface preparation holds down costs and reduces environmental and worker exposures to hazardous dusts. Extensive surface preparation is also more likely to cause mechanical damage to an old, marginally adherent, embrittled coating that may later delaminate.

3.2.3.3. Pitting: Pits often contain active corrosion cells (due to chlorides or sulfates) which can cause early failure of overcoat materials.

3.2.4 Coating Compatibility: Patch testing is a good method of determining whether the new coating is compatible with the existing one. The test should be performed so that the worst-case exposure to the patch is achieved. A method for patch testing is described in SSPC-PA Guide 5 and ASTM D 5064. (See Appendix A.1.2 for an example utilizing a test patch.)

3.2.5 Type of Structure

3.2.5.1 Configuration of Surfaces: Wide planar areas may delaminate first, particularly if the coating is applied over mill scale.

3.2.5.2 Flexing: The rigidity of the coated surface affects how the internal stresses in the coating are translated to interfaces. Flexible beams and wide planar areas tend to contribute more stress to a coating system than more angular, smaller planar areas.

3.2.6 Exposure Environment: The coating selected must be able to withstand the environmental conditions to which it will be exposed, as well as the surface conditions over which it is applied. Rapid thermal cycles tend to stress aged coatings,

causing delamination at the weaker interfaces.

3.3 APPLICATION, SERVICE AND COST CONSIDERATIONS: The items below should be considered when determining whether overcoating is the most appropriate maintenance strategy for a particular situation.

3.3.1 Application Considerations

3.3.1.1 Limitations on Surface Preparation Methods: In some locations, because of noise or emission considerations, some methods of surface preparation cannot be used. As a result, complete removal and replacement of existing coating may not be an option. The preferred treatment would then be a limited surface preparation and overcoating.

3.3.1.2 Limitations on Application Methods: Some environmental or local restrictions prohibit certain application methods or coating products. It must be determined if the permissible application methods (e.g., brushing and rolling) are suitable for the overcoating product selected or considered.

3.3.1.3 Overcoatability of the Coating: Certain existing coatings can only be overcoated after major surface preparation such as scarifying the surface by sweep blasting or power tool cleaning. This situation may reduce or eliminate the economic and environmental advantages of the overcoat strategy.

3.3.2 Service Considerations

3.3.2.1 Expected Remaining Service Life of the Structure: The specifier should determine the remaining service life (in years) of the structure. The cost of overcoating (including surface preparation, containment, materials, application, etc.), may not be justified for a structure to be replaced or decommissioned in a short time.

3.3.2.2 Expected Life of the Overcoat System (in years): The expected service life of the overcoat system is also a critical factor. Unfortunately there is a high degree of uncertainty in these projections. This uncertainty can be conveyed by assigning a range of years for the overcoating system lifetime (e.g., 4-12 years).

3.3.2.3 Risk Threshold of Failure: The specifier must recognize that there is some chance of a catastrophic or premature failure of an overcoat system. Overcoating may not be a viable option if the risk of a coating failure cannot be tolerated. While the decision to use an overcoating strategy is independent of the lead paint issue (lead may not be present), the presence of lead makes all the options more costly. If the overcoat causes a catastrophic failure, the environmental risks are significantly increased. There are various means to reduce the risk of a catastrophic failure. For example, total removal of a poor to marginally adhered existing coating, with new

coatings subsequently applied, provides less risk than some overcoat strategies.

3.3.3 Cost Considerations

3.3.3.1 Comparing Cost of Overcoating and Full Removal: The specifier should estimate the cost of overcoating versus the cost of total removal of coating versus replacement of the steel. Assessment of these options, along with expected coating lifetimes and risks of failure, will aid in determining if overcoating is the most cost-effective option. If the overcoat option causes a catastrophic failure, not only is the cost of the investment lost, additional costs for repair and environmental cleanup could be incurred.

3.3.3.2 Continued Presence of Lead: Another important difference between overcoating and full removal is that full removal permanently eliminates the lead hazard. If the structure is coated with material that must be treated as a hazardous waste, such as a lead-based coating, a latent hazard will exist (whether or not an overcoating system is applied) until the lead-based coating is removed. In cases requiring elimination of potential hazards resulting from disturbance of lead-based coatings, overcoating is not a feasible maintenance strategy.

3.3.3.3 Necessity of Structural Preservation: The specifier should determine if the structure is still needed or whether demolition or abandonment is a possibility. This option will also entail costs; in particular, there would be a need to address worker handling of the lead coated structure components.

3.3.3.4 Cost and Logistics of Structural Replacement: Depending on where a structure is in its design life, it may be more cost-effective to replace the structure than to repaint or overcoat it. Factors such as usage, alternate traffic routes (for bridges), and the availability of alternate structures can affect this decision. The costs for demolition must also be taken into account.

3.3.3.5 Urgency of Action: The specifier should also determine if maintenance can be put off for a period of time.

3.4 Assessing Risk in Overcoating: The coatings engineer may assess the risk associated with overcoating by compiling historical data, performing visual and physical inspections, and by applying coating test patches.

3.4.1 Coating History and Previous Overcoat Experience: The designer should compile as much historical information on the aged coating, surface preparation, and structure as possible. Historic data is commonly available on types of coating, number of coating layers, coating thickness, surface preparation, periodic maintenance, and periodic inspections. It should be determined if lead or any other hazardous material is present in order to properly assess the risks. If other structures have been painted in a similar or identical manner and subsequently

overcoated, this information may also be useful. Information specific to the structure's exposure environment such as the presence of acid precipitation, chemical splash or vapors, or wind-borne or de-icing salts, may also be useful.

If no historic records of coating types exist, ASTM D 5043 can be used to determine the types of coatings on the structure.

The original surface preparation and substrate condition may be determined by using a chemical paint stripper to remove the aged coating from a small area. Intact mill scale, underfilm corrosion, and blast profile can then be determined in this way.

3.4.2 Visual Inspection: A quantitative visual inspection of the aged coating system should be conducted to determine the extent of degradation including underfilm corrosion, chalking, peeling, flaking, cracking, checking, rusting, and blistering. Visible surface contaminants including mildew, debris, grease, and oil should be identified. Representative components or areas of the structure should be individually evaluated. ASTM D 5065 provides a detailed description of the visual inspection techniques that should be utilized.

3.4.3 Physical Inspection: A physical inspection of the structure and aged coating system should be conducted to determine the film thickness, number of layers of paint, adhesion, underlying substrate condition, coating type, and presence of soluble salt contamination. The number of test locations examined must be enough to provide a representative picture of all major conditions existing on the structure.

Table 1 in Appendix A.1 contains a simple algorithm for assessing the risk of overcoating based on film thickness and adhesion of the existing coating. Coatings are categorized by thickness in three ranges: 0 to <10 mils (0 to 254 micrometers), 10 to 20 mils (254 to 508 micrometers), and >20 mils (>508 micrometers). Adhesion is measured in accordance with ASTM D 3359 and film thickness by SSPC-PA 2. The algorithm works on the principle that the risk of failure increases with increasing film thickness and decreasing adhesion. Risk is categorized as OK (essentially no risk), LR (low risk), MR (moderate risk), HR (high risk), and NO (not a candidate for overcoating). See Appendix A, section A.1.1.

Alternatively, ASTM D 4541 can be used to assess the adhesion of the aged coating. In a survey of SSPC member paint manufacturers, minimum tolerable pull-off adhesion values of 50 to 300 psi (340 to 2040 kPa) were cited as necessary for overcoating. Lenhart and El-Naggar have suggested the pull-off adhesion values of 100 to 200 psi (680 kPa to 1360 kPa) are marginal for overcoating and that adhesion of 250 to 600 psi (1700 to 4080 kPa) is acceptable for overcoating.

The thickness of the aged paint system may also be determined using ASTM D 4138. The method is convenient for assessing the number and thicknesses of individual coating layers.

Various methods have been used to determine the level of soluble salt contamination on steel structures including swabbing retrieval, retrieval by magnetic limpet, and retrieval by